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PERFORMANCE ANALYSIS OF PAPR REDUCTION FOR STBC MIMO-OFDM BY USING MODIFIED PTS TECHNIQUES FOR DIFFERENT MODULATION

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ABSTRACT

Higher bandwidth for wireless communications is today's requirement. To meet the requirements new systems are being implemented. These systems are specified by multi carrier frequencies, high data transmission rate and mobility and are implemented with MIMO OFDM (Multiple Input Multiple Output Orthogonal Frequency Division Multiplexing). Integration of STBC to MIMO OFDM over frequency selective channel is adopted to improve further performance which convert frequency selective channel to several flat fading channels thereby eliminating ISI. But the multicarrier technique STBC MIMO-OFDM has high Peak-to-Average Power Ratio (PAPR). To achieve better performance this PAPR has to be reduced. In this paper, the effect on PAPR by variation of different parameters like number of subcarriers, OFDM symbols, and modulation techniques has been presented. We use lower order modulation like QPSK and higher order modulation like 32-QAM which will provide reduction in original PAPR but reduced PAPR will show small difference for low to high modulation. The basic idea of PTS is to produce alternative transmit sequences seeded from the same data source and then to select the transmit signal exhibiting the lowest PAPR. Results show that there is only small difference in PAPR reduction for different subcarriers. But when OFDM symbols are varied, there is recognizable reduction in PAPR. Thus, different subcarriers have minimum influence on PAPR performance compared to OFDM symbol variation.

KEYWORDS: OFDM, MIMO, STBC, Modified PTS, ISI, QPSK

INTRODUCTION

Wireless digital communications are rapidly expanding, resulting in a large demand for wireless systems which are reliable and have a high spectral efficiency. With the constant demand of high spectral efficiency and high transmission speed for audio, video and internet applications, Multiple Input Multiple Output-Orthogonal Frequency Division Multiplexing i.e. MIMO-OFDM has become the most promising technology combination for present and future wireless communications. MIMO offers spatial diversity and therefore increase the capacity while OFDM allow systems to work in time varying or frequency selective environment [1].

MIMO take advantage of the spatial diversity obtained by placing separate antennas in a dense multipath scattering environment. MIMO is implemented in a number of different ways to obtain either a diversity gain or to enhance the channel capacity [3]-[4]-[5]. Space Time Block Coding (STBC) is an effective and practical way to implement with MIMO to improve the reliability of the transmission, as redundant copies of the original data are sent over independent fading channels. To achieve full transmit diversity for given number of antennas the codes are orthogonal. However, the main limitation of using MIMO-OFDM suffers with the problem of high PAPR and carrier frequency offset sensitivity. Hence, it is important to reduce the PAPR; otherwise, high power amplifiers (HPA) in the transmitter need to have a linear region that is much larger than the average power, which makes them expensive and inefficient. This is because if an HPA

with a linear region slightly greater than the average power is used, the saturation caused by the large peaks will result in inter modulation distortion. The intermodulation of signal results in increase of the bit error rate (BER) and spectral widening, which generates adjacent channel interference (ACI).

The design of a system with lower PAPR depends on requirement of system and different parameters are taken in to account for the same. The various parameter are transmit power, data rate, BER, computational complexity (receiver end). A number of techniques were proposed to control the PAPR as partial transmit sequences (PTS)[9]-[11], selective mapping (SLM)[6]-[7], clipping, clipping and filtering[12], coding, tone reservation (TR) and tone injection (TI)[15].

Among these, PTS and SLM techniques are popular phase optimization techniques as they can obtain better PAPR performance without distortion by generating and selecting the optimum candidate.

PAPR IN MIMO-OFDM

An OFDM data block with N subcarriers with $X_k=(X_0 ,X_1,......,X_{N-1})$, is formed with each symbol modulating the corresponding subcarrier from a set of subcarriers. For MIMO-OFDM system, N=subcarriers chosen to be orthogonal, over the period $0 \leq t \leq T$ where, T = original data symbol period, and $f_0=1/T$ is the frequency spacing between adjacent subcarriers.

The complex baseband OFDM signal for N subcarriers is defined as

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi k f_0 t} \text{ , } 0\leq t \leq T \tag{1}$$

Replacing $t=nT_b$, where $T_b=T/N$, gives the discrete time version is written as

$$x(t) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X_k e^{j2\pi kn/LN} \text{ , } n=0,1,\ldots, NL-1 \tag{2}$$

where L = oversampling factor.

The sampling can be implemented by an inverse fast Fourier transform (IFFT).

The PAPR of the transmitted OFDM signal, x(t), is defined as the ratio between the maximum instantaneous power and the average power, defined by

$$PAPR = \frac{max_{0\leq t\leq T}|x(t)|^2}{E[|x(t)|^2]} \tag{3}$$

where E [・] is the expectation operator.

The theoretical maximum of the PAPR for N number of subcarriers is as follows,

$$PAPR_{max}=10\log(N) \text{ dB} \tag{4}$$

PAPR is a random variable, because it is a function of the input data and the data are random variable. Therefore PAPR can be calculated by using level crossing rate that calculates the average number of times that the envelope of a signal crosses a given level. Knowing the amplitude distribution signals probability of instantaneous amplitude above threshold can be easily calculated and it is applicable for power also. This is performed by calculating complementary cumulative distribution function for different PAPR values as:

$$CCDF=P_r(PAPR>PAPR_0) \tag{5}$$

where P_r=probability value

PAPR=instantaneous value

$PAPR_0$=threshold value

Influencing Factors of PAPR

PAPR is closely related to modulation schemes, number of sub-carriers and oversampling rate.

Modulation schemes

Different modulation schemes produce different PAPR performance. A set of CCDF curves which are processed by several commonly used modulation schemes like BPSK, QPSK, 16QAM and 64QAM with the number of sub-carriers.

Number of Sub-Carriers

Different number of sub-carrier results in different PAPR performances due to the varying information carried. When the number of sub-carriers increases, the PAPR also increase. Therefore, the number of sub-carrier is a very important influence factor on the PAPR.

Oversampling Rate

In real implementation, continuous-time OFDM signal cannot be described precisely due to the insufficient N points sampling. Some of the signal peaks may be missed and PAPR reduction performance is unduly accurate. To avoid this problem, oversampling is usually employed, which can be realized by taking $L \cdot N$ point IFFT/FFT of original data with $(L-1) \cdot N$ zero-padding operation. Over-sampling plays an important role for reflecting the variation features of OFDM ls in time domain. 4. No. of symbols

In this paper we are discussing PAPR variation by varying no. of subcarriers and symbols.

Space-Time Codes

Previously, multipath fading in multiple antenna wireless systems was mostly dealt with by other diversity techniques, such as temporal diversity, frequency diversity and receive antenna diversity, with receive antenna diversity being the most widely applied technique. However, it is hard to effectively use receive antenna diversity at the remote units because of the need for them to remain relatively simple, inexpensive and small. Therefore for commercial reasons, multiple antennas are preferred at the base stations, and transmit diversity schemes are growing increasingly popular

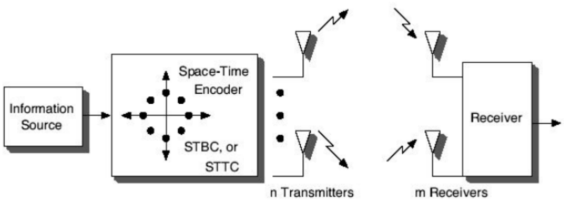

Figure 1: System Block Diagram for STC

as these can be implemented for high data rate transmission over wireless fading channels in both the uplink and downlink path with diversity implementation at the base station. There are two main types of STCs, namely space-time block codes (STBC) and space-time trellis codes (STTC). Space-time block codes operate on a block of input symbols,

producing a matrix output whose columns represent time and rows represent antennas et al [20].

Space-time block codes are designed to achieve the maximum diversity order for the given number of transmit and receive antennas and space-time block codes a very popular and most widely used scheme.

Alamouti scheme is the base of the Space Time Coding technique. At the transmitter side, a block of two symbols is taken from the source data and transmitted to the modulator. After that, Alamouti space-time encoder takes the two modulated symbols, in this case called s1and s2 creates encoding matrix S where the symbols s1 and s2are mapped to two transmit antennas in two transmit time slots. The encoding matrix is represented as below.

$$S = \begin{pmatrix} s_1 & s_2 \\ -s_2^* & s_1^* \end{pmatrix}$$

Modulation Techniques

Digital modulation techniques are having higher capacity than analog modulation techniques.

Digital modulation techniques are

- QPSK (Quadrature Phase Shift Keying)
- FSK (Frequency Shift Keying)
- MSK (Minimum Shift Keying)
- QAM (Quadrature Amplitude Modulation)

In this paper, QPSK and QAM techniques are implemented to observe effect of PAPR on number of sub carrier and different OFDM symbols. Quadrature Phase Shift Keying (QPSK) uses, two successive bits in the data sequence are grouped together. This combination of two bits forms four unique symbols. When the symbol is transited to next symbol, then the phase of the carrier is shifted by 45^0 or (Π/4 radian). Quadrature Amplitude Modulation uses the phase and amplitude of the carrier signal to encode data. The QAM scheme encodes data by varying both amplitude and phase of the carrier signal. Or it is sometimes viewed as a combination of ASK and PSK modulation.

PAPR REDUCTION TECHNIQUES

The PAPR reduction methods are divided into three major categories as Signal distortion techniques, Signal scrambling techniques and Coding techniques. Some powerful schemes are the signal scrambling techniques, contains Selective Level Mapping (SLM) & Partial transmit sequence (PTS) among which PTS is used for the work. In this paper PTS technique is used for reducing PAPR [14]. The complexity and computation time is minimum compared to others. In a typical OFDM system with PTS approach several full IFFT operations are avoided in PTS, which is its advantage over SLM.

Partial Transmit Sequence

Principle of PTS (Partial Transmit Sequence)

The basic idea of partial transmit sequences algorithm is to divide the original OFDM sequence into several sub-sequences, and for each sub-sequence, multiplied by different weights until an optimum value is chosen.

Selected Mapping Algorithm

Selected mapping (SLM) is scrambling technique. It uses to select the data from phase rotated input data block. It selects the most favorable signal (having low PAPR) from a set of phase rotated candidate data blocks generated by transmitter, which are all represent the same information as the original data block.

In SLM the transmission of side information is required so that the receiver can use the it to determine which candidate block is selected in the transmission and then recover the information. SLM technique leads additional complexity, and loss in efficiency.

However, the PTS PAPR reduction scheme's performance improvement is achieved at the expense of high complexity and difficult parameter setting problems. Therefore, modified PTS indeed use the potential of MIMO transmission for PAPR reduction.

System Architecture

A block diagram of STBC MIMO-OFDM system with Mt=2 transmit antennas is given below in Figure2.

- A data symbol vector S=[X_0, X_1 ,……..X_{N-1}] is encoded with space-time encoder into two vectors as follows

  S_1=$[X_0, -X_1^*, \dots \dots X_{N-2}, -X_{N-1}^*]^T$

  S_2=$[X_1, -X_0^*, \dots \dots X_{N-1}, -X_{N-2}^*]^T$

  Symbol S1 and S2 represent the two neighboring OFDM signals in time domain.

Serial input data first passes through the serial to parallel converter. Then the parallel signal is mapped with QPSK modulation to generate the data block S. It is further partitioned into V disjoint subblocks S1, S2, ... ,Sv . A subblock Sm (m=l, 2, ... , V) is mapped into a set of symbol sequences, which are fed to the IFFT blocks and sent simultaneously from antennas TX1 and TX2, respectively.

- All subcarriers positions which are occupied in another sub-block are set to zero. Each of the blocks, has an IFFT performed on it.

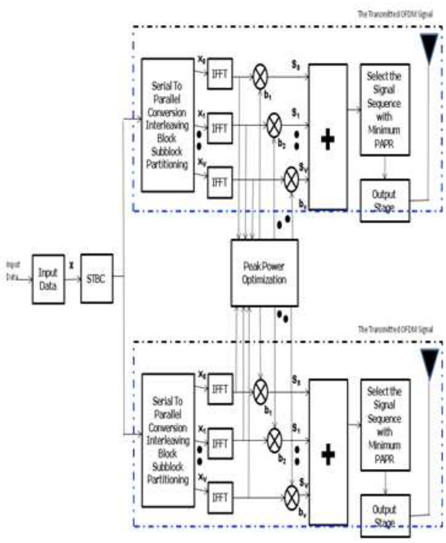

Figure 2: Block Diagram of STBC MIMO-OFDM System with Mt=2 Transmit Antennas

The output of each block except for first block which is kept constant, is phase rotated by the rotation factor as given by

$$e^{j\theta(v)}\epsilon[0,2\pi]$$

- The blocks are then added together to produce alternate transmit signals [9].
- Each alternate transmit signal is stored in memory and the process is repeated again with a different phase rotation value. After a set number of phase rotation values.
- The weighting rotation parameter set is chosen to minimize the PAPR. The computational complexity of PTS method depends on the number of phase rotation factors allowed.
- To increase the potential capability of PAPR reduction performance for the PTS method, these phase factors combination correctly maintains the orthogonality between the different modulated carriers.
- However, the PTS PAPR reduction scheme's performance improvement is achieved at the expense of high complexity and difficult parameter setting problems. Therefore, modified PTS indeed use the potential of MIMO transmission for PAPR reduction.

SIMULATION AND DISCUSSIONS

To evaluate the performance of modified PTS technique for different number of sub-blocks, we simulate it using MATLAB 7.12. PAPR reduction performance depends on the number of subcarriers N and the number of OFDM symbols. In this paper we study the effects of subcarriers and OFDM symbols.

Table 1: Parameters Used in Simulation

Information	Parameters
Modulation	QPSK, 8-QAM, 16-QAM, 32-QAM
Number of subcarriers(N)	64,128,256,512
Number of OFDM symbols(U)	4,8,16
Number of sub-blocks(V)	4
Number of transmitting antenna(Tx)	2
Number of phase factor(W)	4

Figure 3 display the PAPR reduction using modified PTS method with different subcarrier, in which modulation scheme, QPSK is applied, V=4. From this figure it is observed that PAPR reduction for N=64, N=128, N=256, N=512, PAPR reduction is not recognizable for two transmitting antenna with variable subcarrier and W=4.

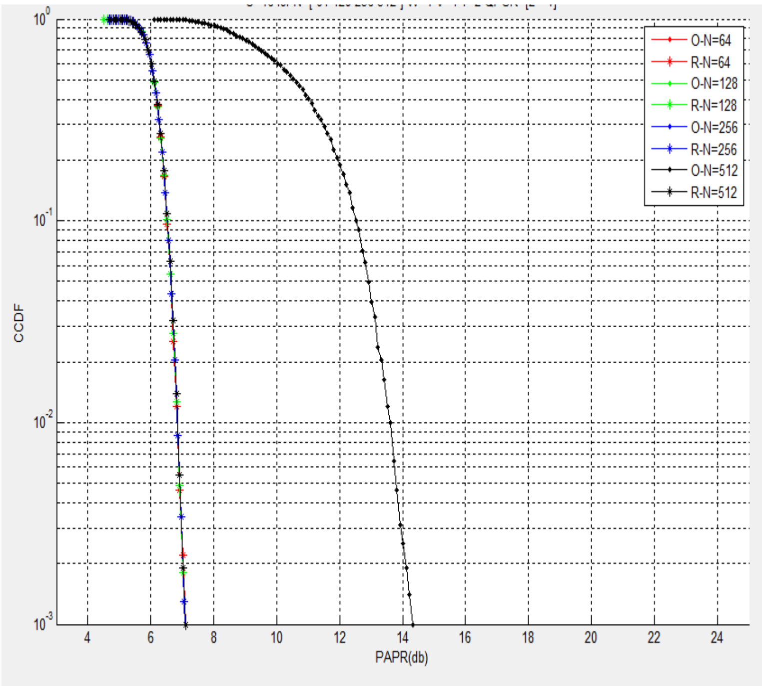

Figure 3: CCDF of PAPR for QPSK Modulation using Different Subcarriers When v=4 with tx=2 Transmit Antenna

Figure 4 displays PAPR reduction for QPSK modulation using different OFDM symbol using two transmitting antenna and V=4. Figure shows the reduction in PAPR according to the OFDM symbol candidate increases.

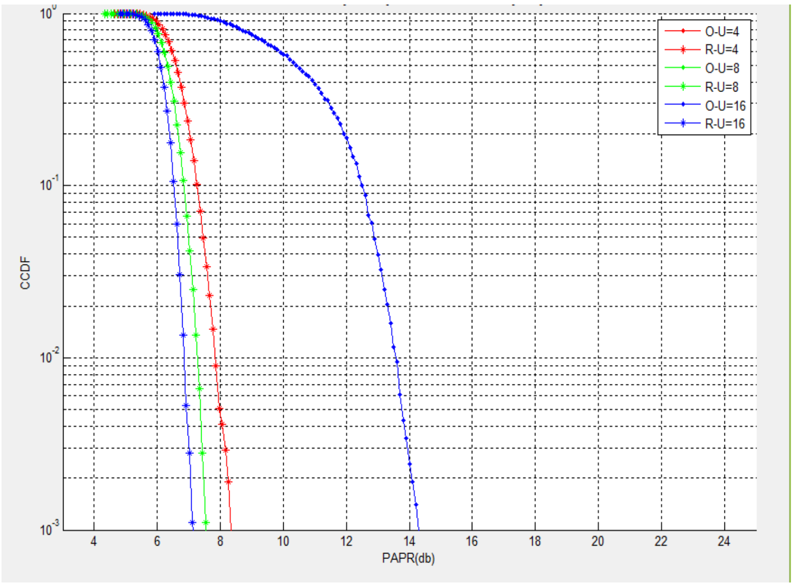

Figure 4: CCDF of PAPR for QPSK Modulation Using Different OFDM Symbols When V=4 with Tx=2 Transmit Antenna

Figure 5 displays the PAPR reduction using modified PTS method with different subcarriers, in which modulation scheme,8-QAM is applied. For 8-QAM, result shows PAPR reduction using different subcarriers almost equal as QPSK but original PAPR is increased.

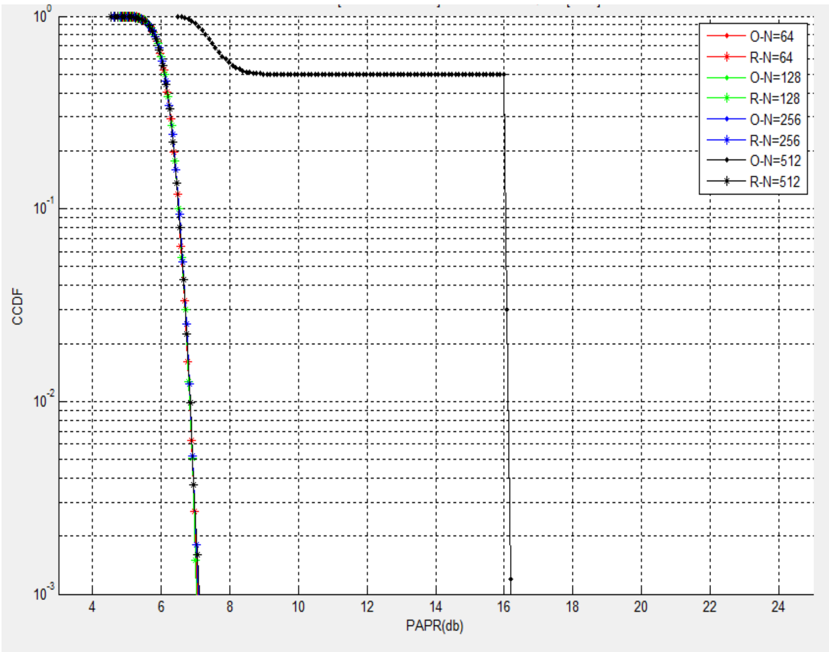

Figure 5: CCDF of PAPR for 8-QAM Modulation Using Different Subcarriers When V=4 with Tx=2 Transmit Antenna

Figure 6 displays CCDF of PAPR for 8-QAM modulation using different OFDM symbols when V=4 with Tx=2 transmit antenna.

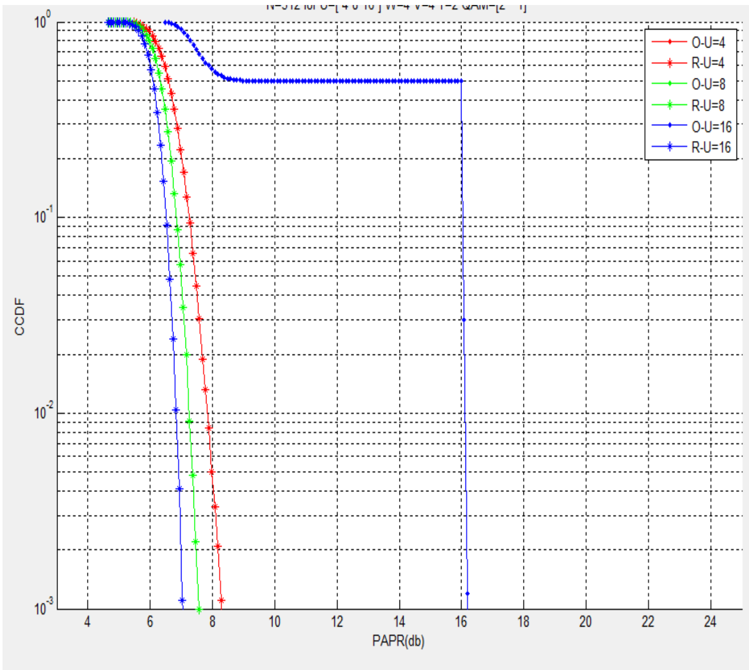

Figure 6 CCDF of PAPR for 8-QAM Modulation Using Different OFDM Symbols When V=4 with Tx=2 Transmit Antenna

Figure 7 displays the PAPR reduction using modified PTS method with different subcarriers, in which modulation scheme, 16-QAM is applied. For 16-QAM, result shows PAPR reduction using different subcarriers almost equal as QPSK but original PAPR is increased.

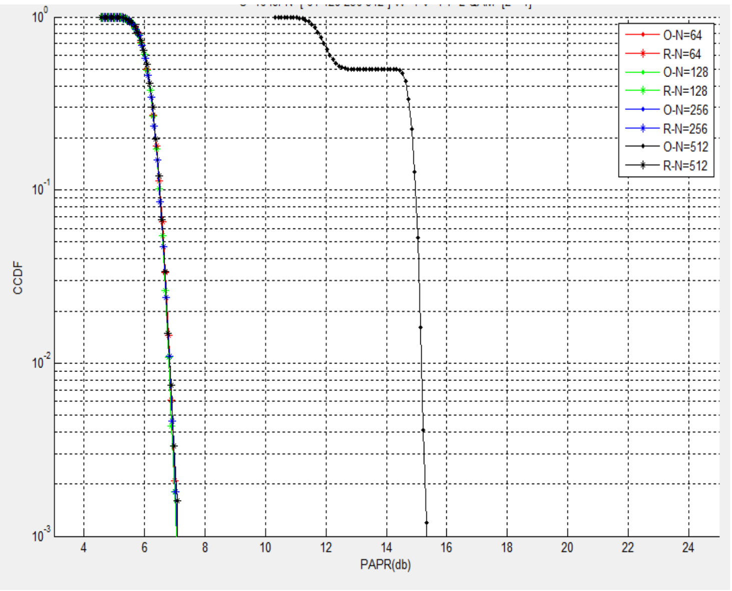

Figure 7: CCDF of PAPR for 16-QAM Modulation Using Different Subcarriers When V=4 with Tx=2 Transmit Antenna

Figure 8 displays CCDF of PAPR for 16-QAM modulation using different OFDM symbols when V=4 with Tx=2 transmit antenna.

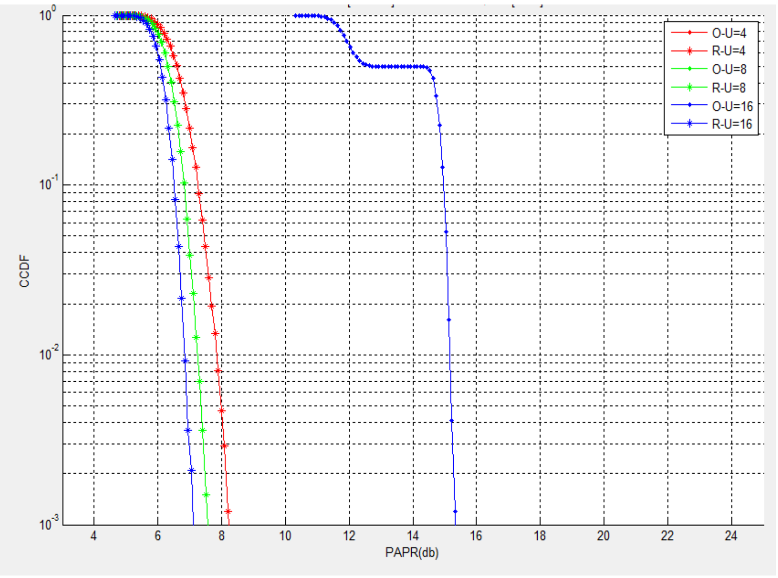

Figure 8: CCDF of PAPR for 16-QAM Modulation Using Different OFDM Symbols When V=4 with Tx=2 Transmit Antenna

Figure 9 displays the PAPR reduction using modified PTS method with different subcarriers, in which modulation scheme, 32-QAM is applied. For 32-QAM, result shows PAPR reduction using different subcarriers almost equal as QPSK but original PAPR is increased.

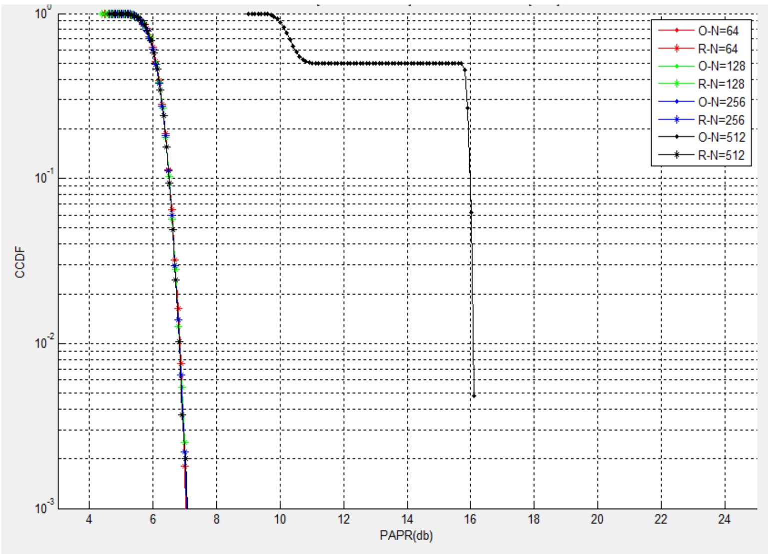

Figure 9: CCDF of PAPR for 32-QAM Modulation Using Different Subcarriers When V=4 with Tx=2 Transmit Antenna

Figure 10 displays PAPR reduction for 32-QAM modulation using different OFDM symbol using two transmitting antenna and V=4. Figure shows the reduction in PAPR according to the OFDM symbol candidate increases.

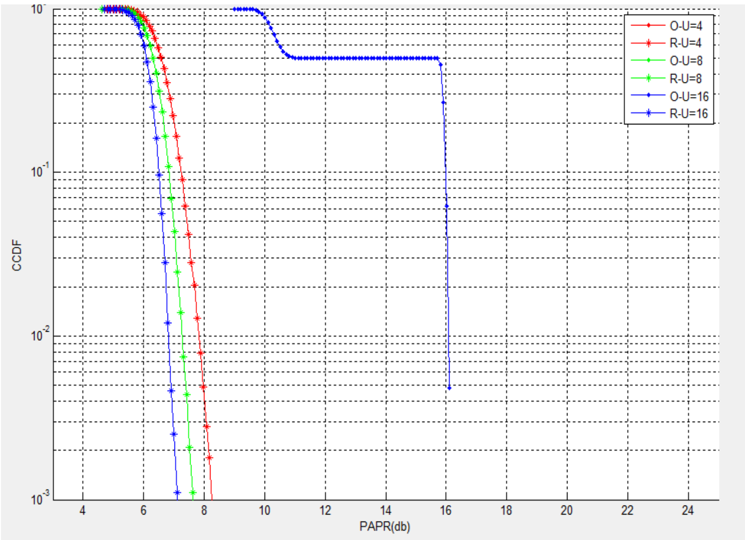

Figure 10: CCDF of PAPR for 32-QAM Modulation Using Different OFDM Symbols When V=4 with Mt=2 Transmit Antenna

Figure 11 displays CCDF of PAPR comparison for QPSK verses 32-QAM with V=4, W=4, N=128,U=16 and Tx=2.

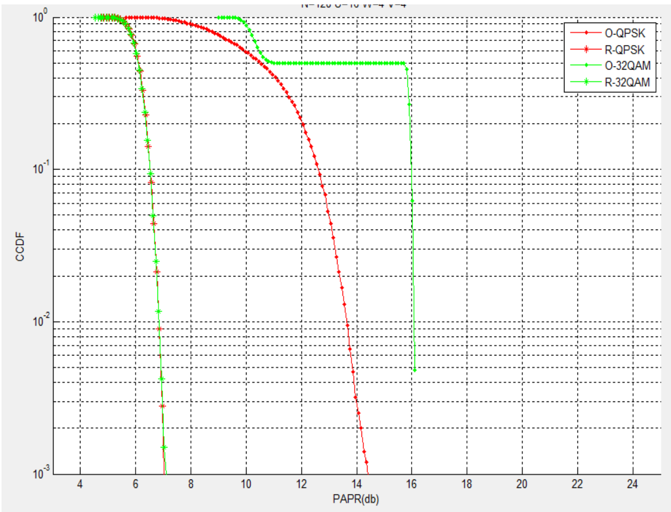

Figure 11: CCDF of PAPR for 32-QAM verses QPSK Modulation Using Different Subcarriers When V=4 with Tx=2 Transmit Antenna

CONCLUSIONS

MIMO-OFDM offers high data rates due to its design that performs better robust against the multipath fading and inter-symbol interference(ISI). MIMO-OFDM system can be implemented using higher order modulations to achieve large data capacity. This paper focuses on major drawback of OFDM signal which is high PAPR. The PTS provides a distortion less technique in eliminating the PAPR at the expense of additional complexity. In this paper, the analysis of PAPR reduction is based on varying the number of subcarriers and OFDM symbols for higher order modulations. It can be seen that MIMO-OFDM system can significantly increase the channel capacity of the system with the inclusion of more antenna to the system.

REFERENCES

1. Simon Haykin, Digital Communication, chapter 8, Wiley publishers, 1988.
2. S. M. Alamouti, “A simple transmitter diversity scheme for wireless communications,” IEEE J. Select. Areas Commun., vol. 16, pp. 1451–1458, Oct. 1998.
3. R. V. Nee and R. Prasad, OFDM for Wireless Multimedia Communications, London, Artech House, 2000.
4. Jing Gao, Jinkuan Wang and Yun Wang, "A low complexity PAPR reduction technique for STBC MIMO-OFDM SYSTEM", in Proceedings of International Conference on Wireless Communications, Networking and Mobile Computing, Shanghai, 21-25 September 2007.
5. V. Tarokh, N. Seshadri, and A. R. Calderbank, \Space-time codes for high data rates wireless communications: Performance criterion and code construction," IEEE T r ans. Inform. Theory, vol. 44, pp. 744{765, 1998.
6. Z. Xiuyan and T. Guobin, "The research of improved PTS method for peak-to -average power ratio reduction", in Proceedings of 3rd international conference on wireless. mobile and multimedia networks, Beijing, China, 26-29 September 2010.
7. R. Baumal, R. Fischer, and J. Huber, ―Reducing the peak-to-average power ratio of multicarrier modulation by selective mapping,‖IEEE Electronics Letters, vol. 32, no. 22, pp. 2056-2057, October 1996.

8. S. H. Han, J. H. Lee, “An Overview of Peak – to – Average Power Ratio Reduction Techniques for Multicarrier Transmission”, IEEE Transaction on Wireless Communication, April 2005.
9. P . Mukunthan and P Dananjayan, “PAPR Reduction based on a Modified PTS with Interleaving and Pulse Shaping method for STBC MIMO-OFDM System”, IEEE conference publication on ICCCNT 2012.
10. Rick S. Blum, Ye (Geoffrey) Li, Jack H. Winters, and Qing Yan, “Improved Space–Time Coding for MIMO-OFDM Wireless Communications,” IEEE transactions on communications, VOL. 49, NO. 11, NOVEMBER 2001.
11. D. Phetsomphou, S. Yoshizawa, and Y Miyanaga, "A partial transmit sequence technique for PAPR reduction in MIMO-OFDM systems", in Proceedings of 10th international Symposium on Communications and Information Technologies, Tokyo, Japan, pp. 672-67 6, 26-29 October 2010.
12. Shang-Kang Deng, Mao-Chao Lin, ―Recursive Clipping and Filtering with bounded distortion for PAPR reduction,‖ IEEE Transactions on Communication, vol. 55, no. 1, pp. 227-230, January 2007.
13. Jaturong Sarawong, Tanairat Mata,” Interleaved Partitioning PTS with New Phase Factors for PAPR Reduction in OFDM Systems,” in Proceedings of 8" International Conference on Electrical Engineering / Electronics. computer, Telecommunications and Information Technology, Khon Kaen, Thailand, pp. 361-3 64,17- 20 May 2011.
14. L. J. Cimini and N. R. Swollen berger, “Peak-to-average-power ratio reduction of an OFDM signal using partial transmit sequences,” IEEE commun. Lett. Vol. 4, no. 3, March 2000.
15. C. Tellambura, ―Phase optimization criterion for reducing peak-toaverage power ratio of an OFDM signal,‖IEEE Electronics Letters,. vol. 34, no. 2, pp. 169-170, January 1998.
16. A. D. S. Jayalath, C. Tellambura and H. Wu, ―Reduced complexity PTS and new phase sequences for SLM to reduce PAP of an OFDM signal,‖ Proceedings of IEEE 51st Vehicular Technology Conference, Tokyo,Japan, 2000.
17. Xinchun Wu, Zhigang Mao, Jin xiang Wang, Bin Zho., " A novel PTS technique with combinative optimization in real part and imaginary part for PAPR reduction in OFDM systems", in Proceedings of Third International Conference on Next Generation Mobile Applications, Services and Technologies, Cardiff, Wales, UK, 15-18 September 2009.
18. Harish Reddy and Tolga M. Duman, ―Space-time coded OFDM with low PAPR‖, Proceedings of Global Telecommunications Conference, San Francisco, USA, 1-5 December 2003, vol. 2, pp. 799-803.
19. Mata. T, “A new weighting factor with concurrent PAPR reduction algorithm for STBC MIMO-OFDM,” IEEE, 15-17 Dec. 2009.
20. Lei Poo, "Space-Time Coding for Wireless Communication:A Survey" Stanford University.